Final Techical Report

Contract Title: Methodology for Developing Realtime Distributed Systems

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1. **Technical Objectives:** The goal of this effort was to develop a methodology for establishing properties of realtime distributed operating systems. The major issues addressed include approaches to time and calendar management, verifiable kernel for meeting realtime constraints for aperiodic as well as periodic tasks, and distributed resource management schemes.

2. **Approach:** The starting point in this effort was a complete evaluation and assessment of the current technology for realtime systems. This assessment was undertaken from theoretical as well as practical considerations. Our approach was to design an object based distributed system in which time properties of each object are explicitly represented and supported. The design was to be assessed through theoretical evaluation followed by a prototype implementation.

3. **Techical Accomplishments :**

   The assessment of the current state of the art of realtime programs and systems has been completed. While many realtime systems have been developed and used over the years nearly all use a centralized approach and have a static, priority based scheduling of resources. As a consequence it is not possible to guarantee the meeting of hard deadlines in most of these systems.

   We have completed an initial design and implementation of a distributed realtime operating system MARUTI. MARUTI is a hard realtime, fault tolerant, distributed, reactive operating system. It provides a guarantee to each of its accepted jobs that its deadlines are met, supports distributed computations and allocates resources to support fault tolerance goals.

4. **Significance:** With the basic design of the operating system MARUTI we are addressing the major problems associated with the use of distributed systems in realtime environments for mission critical applications which must operate in a distributed environment while meeting the hard real-time, reliability and security requirements. The unique approach to calendar management and resource allocation in the design of MARUTI permits it to be effective in hard-realtime environments. The fault handling capabilities are built as an integral part of the the design of this system. Capability based security operations which can be carried out without violating the real-time operational requirements have also been incorporated in the system.

5. **Publications List:**

   - Levi and Plateau, "A Distributed Algorithm for Deadlock and Termination Detection of Distributed Computations", *The Second International Symposium on Computer and Information Sciences*, Istanbul, Turkey, October 1987, pp 111-133 (Also CS-TR- 1750).

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- Levi and Agrawala, "Realtime Programs: Design Implementation and Validation (A Survey)," CS-TR-1837, Department of Computer Science, University of Maryland, College Park, MD, April 1987.

- Levi and Agrawala, "On Realtime Operating Systems," CS-TR-1838, Department of Computer Science, University of Maryland, College Park. MD. April 1987.

- Levi and Tripathi, "On Realtime Systems Using Local Area Networks," CS-TR-1892, Department of Computer Science, University of Maryland, College Park. MD, April 1987.

- Levi and Agrawala, "Objects Architecture: A comprehensive Design Approach for Realtime, Distributed, Fault Tolerant Reactive Operating Systems," *The Fourth Workshop on Realtime Operating Systems,* Cambridge, Mass., July 1987. pp 142-148 (Also CS-TR-1915).

- Tripathi, Chintamaneni, Jalote, Shieh, "On Fault Tolerance in Manufacturing Systems," CS-TR-1929, Department of Computer Science, University of Maryland, College Park, MD, October 1987, also in IEEE Networks, Vol 2 No. 3, pp. 32-39, May 1989.

- Agrawala and Levi, "Temporal Relations and Structures in Real-Time Operating Systems," CS-TR-1954, Department of Computer Science, University of Maryland, College Park, MD, December 1987.

- Agrawala and Levi, "Scheduling in real-Time Distributed Systems–A Review," CS-TR-1955, Department of Computer Science, University of Maryland, College Park, MD, December 1987.

- Agrawala, Tripathi, Chintamaneni, and X. Yuan, "Scheduling Tasks in a Real-Time System," CS-TR-1991, Department of Computer Science, University of Maryland, College Park, MD, February 1988.

- Nehmer, "An Object Architecture for Hard Real-Time Systems," CS-TR-2003. Department of Computer Science, University of Maryland, College Park, MD, March 1988.

- Agrawala, Levi, and Mosse, "Allocation of Real-Time Computations under Fault Tolerance Constraints,"CS-TR-2018, Department of Computer Science, University of Maryland, College Park, MD, May 1988.

- Nehmer, "A Structuring Framework for Distributed Operating Systems," CS-TR-2079, Department of Computer Science, University of Maryland, College Park, MD, July 1988.